ISSN 0100-2945 DOI: http://dx.doi.org /10.1590/0100-29452018016

Propagation

Revista Brasileira de Fruticultura

Nutrient absorption and accumulation in 'Paulista' and 'Sabará' jabuticaba cultivars

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Abstract- The amount of nutrients accumulated and distributed in young jabuticaba trees are not yet well known. The aim of this work was to verify biomass production, nutrient accumulation and distribution in 'Paulista' and 'Sabará' jabuticaba seedlings. The experiment was conducted in greenhouse and seedlings were propagated by seeds and transplanted after 150 days into pots containing perlite and cultivated for 450 days in nutrient solution. Nutrient accumulation and distribution in the different plant organs (root, stem and leaves) were evaluated every 90 days. The mean total nutrient accumulation of 'Paulista' and 'Sabará' seedlings at 450 days were: N (706 and 611), P (81 and 62), K (541 and 409), Ca (488 and 424), Mg (66 and 54) and S (93 and 92) in mg plant^{-1} and Cu (1578 and 1635), Fe (20887 and 19652), Mn (13975 and 13434), Zn (4921 and 4048) and B (642 and 764) in µg plant^{-1}, respectively. 'Paulista' and 'Sabará' jabuticaba seedlings presented the following tendency of nutrient accumulation and distribution among organs: leaf > stem > root. Thus, this work can be a useful reference for studies on the fertilization management in jabuticaba seedlings.

Index terms: *Plinia caulifora*, *Plinia jaboticaba*, mineral nutrition, nutrient, fruticulture.

Absorção e acumulação de nutrientes em mudas de Jabuticabeiras 'Paulista' e 'Sabará'

Resumo - Ainda não são suficientemente conhecidas as quantidades de nutrientes acumulados e distribuídos em jabuticabeiras jovens. O trabalho objetivou verificar a produção de biomassa, acúmulo e distribuição de nutrientes em mudas de jabuticabeiras 'Paulista' e 'Sabará'. O experimento foi conduzido em casa de vegetação e as mudas foram propagadas por sementes e transplantadas, após 150 dias, para vasos contendo perlita e cultivadas por 450 dias em solução nutritiva. Avaliou-se, a cada 90 dias, o acúmulo e distribuição de nutrientes nos diferentes órgãos das plantas (raiz, caule e folhas). O acúmulo total médio de nutrientes pelas mudas das jabuticabeiras 'Paulista' e 'Sabará', aos 450 dias, foi de: N (706 e 611), P (81 e 62), K (541 e 409), Ca (488 e 424), Mg (66 e 54) e S (93 e 92) em mg planta^{-1} e Cu (1578 e 1635), Fe (20887 e 19652), Mn (13975 e 13434), Zn (4921 e 4048) e B (642 e 764) em µg planta^{-1}, respectivamente. As mudas de jabuticabeiras 'Paulista' e 'Sabará' apresentaram a seguinte tendência de acúmulo e distribuição de nutrientes entre os órgãos: folha > caule > raiz. Dessa forma, este trabalho pode ser uma referência útil para estudos sobre o manejo da adubação em mudas de jabuticabeiras.

Termos para indexação: *Plinia caulifora*, *Plinia jaboticaba*, nutrição mineral, nutriente, fruticultura.

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Received: February 06, 2018.
Accepted: July 26, 2018.

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Introduction

Fruit tree native to Brazil and inserted in the Atlantic Forest Biome, jabuticaba belongs to the family Myrtaceae, genus *Plinia*. *Plinia cauliflora* (Mart.) Berg, known as 'Paulista', 'Açu' or 'Ponhema' jabuticaba and *Plinia jabuticaba* (Vell.) Berg, known as 'Sabará' jabuticaba are among species.

'Paulista' and 'Sabará' jabuticaba cultivars are frequently found in domestic orchards in the states of Minas Gerais, Rio de Janeiro and São Paulo. 'Paulista' cultivar yields large and very productive tree, and its fruits are large in size, with coriaceous bark and is recommended for the production of liqueurs and jellies. 'Sabará' cultivar has small fruits, thin bark and many producers consider it the best variety, and its fruits are widely consumed in the fresh form due to its sweet taste (JOLY, 2002; LORENZI, 2008).

Soil is considered a complex medium for studies related to mineral nutrition. In this way, the use of simpler artificial means, such as cultivation in nutrient solution, allows better control of nutrient proportions and evaluation of plant nutrition (FRANCO & PRADO, 2006). However, few studies have been carried out to verify nutritional aspects in the production of seedlings of species belonging to the family Myrtaceae.

There is no information available in literature on mineral nutrition for initial formation of jabuticaba plants, which implies empirical fertilization recommendations in the cultivation of these species. The knowledge about nutrient accumulation and distribution in plant organs is relevant to meet in a sustainable and adequate way the nutritional requirements for the formation of jabuticaba seedlings. Obtaining absorption curves reveals useful information for estimating the amount of nutrients and determining times when elements are most required, as well as guiding corrections of deficiencies that may occur during plant development.

Studies on mineral nutrition in stevia (*Stevia rebaudiana* (Bert.) Bertoni) (DE LIMA FILHO et al., 1997) and star fruit (*Averrhoa carambola*) (ROZANE et al., 2011a, b) reveal that the nutrient accumulation rates characterize the nutrient absorption dynamics, since the variation observed through nutritional indexes represent the accumulation and redistribution of certain nutrient in the plant or in specific organs and the amount that was absorbed. Thus, the monitoring of nutrients absorbed throughout cultivation as a function of biomass production in the time interval provides the relative nutrient absorption rates (TARN) and organogenic net nutrient accumulation rates (TALON), which are proposed by the formulas of Welbank (1962).

There is no information in Brazilian literature about nutrient uptake in jabuticaba seedlings that use such nutritional indexes. The aim of this study was to determine the nutrient accumulation and distribution, as well as to evaluate the relative absorption rates of macro and micronutrients of 'Paulista' and 'Sabará' jabuticaba species cultivated in nutrient solution.

Material and methods

The experiment was conducted in greenhouse located in the municipality of Sete Lagoas, Minas Gerais (19°28'32.5"S and 44°11'43.4"W) from June 2013 to September 2014. The mean air temperature inside the greenhouse during the experimental period was 26.6°C. Seeds collected *ex situ* from 'Sabará' mother plants in Prudente de Moraes (MG) and 'Paulista' mother plants in São João del-Rei (MG) were used.

The design was completely randomized in subdivided plots with four replicates. In plots, both jabuticaba species ('Paulista' and 'Sabará') were evaluated and, in subplots, five seedling collection periods (90, 180, 270, 360 and 450 days after transplanting - DAT) were evaluated, and each experimental unit was composed of four plants.

The selected seedlings had mean height of 15 cm and were transplanted to the hydroponic system 150 days after sowing to polypropylene pots (11 L) (27 cm in diameter and 25 cm in height) each filled with 10dm³ of perlite (substrate used for cultivation in nutrient solution). Each pot was composed of four seedlings arranged equidistant from each other, each positioned in one quadrant. The nutrient solution was proposed by Castellane and Araújo (1995), indicated by Franco and Prado (2006) as suitable for guava cultivation (Myrtaceae), with the following nutrient concentrations (mg L^{-1}): N = 222.5; P = 61.9; K = 426.2; Ca = 139.9; Mg = 24.3; S = 32.4 and in µg L^{-1}, B = 498, Cu = 48; Fe = 5000; Mn = 419; Mo = 52; Zn = 261.

Jabuticaba seedlings were kept for 15 days for adaptation in nutrient solution diluted to ¼ of the usual concentration and soon after this period, they received complete nutrient solution, renewed every 60 days. The nutrient solution was intermittently sprayed at flow of 0.43 L min^{-1} (10 minutes/hour /day), controlled by a timer that powered the pump to the feed line until 450 days after transplanting. The nutrient solution percolated through the substrate, returning by gravity to the 450 L reservoir kept buried and properly sealed, positioned below the drainage level.

The pH and electrical conductivity (EC) values of the nutrient solution were daily monitored using portable equipment (Cambo model F-HI98130), pH adjusted to 5.5 ± 0.5 with diluted solution of sulfuric (H_2SO_4) and phosphoric acids (H_3PO_4) at proportion of 2:1, respectively solubilized in one liter of deionized water. EC was daily adjusted by the addition of macro and micronutrient stock solutions and maintained at value lower than 2.4 dS m^{-1}, as indicated by Távora et al. (2001) for seedlings of the family Myrtaceae. Evaluations were carried out every 90 days until 450 DAT. At each plant collection, roots were carefully washed in running water for the removal of perlite residues and the plant material was separated into root, stem and leaf. The sectioned plant material was placed in identified paper bags and dried in oven with forced air circulation (65 - 70°C), until reaching constant mass and then weighed in a semi-analytic scale. The dried materials were ground in Willey mill (20 mesh sieve) and stored in 50 ml hermetically sealed polyethylene pots. Subsequently, ground samples were sent for laboratory analysis where the total contents of macro (N, P, K, Ca, Mg and S) and micronutrients (Cu, Fe, Mn, Zn and B) were determined in plant tissues, according to methodology described by Malavolta et al. (1997).

Based on the nutrient and dry matter contents, the accumulation of macro and micronutrients was calculated through TARN and TALON nutritional indexes in the different organs of jabuticaba seedlings, obtained from the following equations 01 and 02, respectively:

1. Relative Nutrient Absorption Rate (TARN) (WELBANK, 1962);

$$TARN = (N_2 - N_1)(\ln M_2 - \ln M_1) / (t_2 - t_1)(M_2 - M_1) \text{ .... } (mg\ g^{-1}\ day^{-1}) \quad \text{(equation 01).}$$

M_1 and M_2 - total mass of the plant referring to times t_1 and t_2, respectively.

2. Organogenic Net Nutrient Accumulation Rate (TALON).

$$TALON = (N_2 - N_1)(\ln M_2 - \ln M_1) / (t_2 - t_1)(M_2 - M_1) \text{ .... } (mg\ g^{-1}\ day^{-1}) \quad \text{(equation 02).}$$

M_1 and M_2 - mass of the plant organ referring to times t_1 and t_2, respectively.

N_1 and N_2 - amount of nutrient in the plant organ referring to times t_1 and t_2, respectively.

ln = logarithm neperian.

Based on the results obtained, in each of the evaluation periods, they were submitted to analysis of variance and F test at 5% of probability. Assumptions of normality of errors and homogeneity of residual variances were tested. Polynomial regression and comparison between jabuticaba species were performed using the Tukey’s test ($P < 0.05$). For statistical analyses, the SISVAR 5.6 software was used (FERREIRA, 2011).

Results and discussion

Table 1 shows the dry matter accumulation results in the different ‘Paulista’ and ‘Sabará’ jabuticaba organs during the 450 days of cultivation.

There was a significant difference for the mean dry biomass accumulation at 450 DAT between jabuticaba species, being the largest accumulation observed in ‘Paulista’ cultivar. This behavior is probably related to intrinsic and genetic factors that will determine the primary and secondary growth habits inherent of the species (Table 1). The Relative Absorption Rate results (TARN), expressed as the amount of absorbed or accumulated nutrient and biomass production in the whole plant and in specific organs (TALON) such as leaves, stems and roots, during a time interval, are presented in table 2.

In general, it was observed that nutrient solution, hydroponic cultivation conditions and experiment execution did not limit the development of jabuticaba seedlings, which consequently resulted in positive TARN values (Table 2).

The highest macronutrient absorption rates (TARN) in the whole plant were observed in the period of 90 - 180 days, except for N, which had the highest absorption in the period of 180-270 and 270-360 DAT, respectively, for ‘Paulista’ and ‘Sabará’ cultivars. After transplanting, due to their more intense metabolism, seedlings had higher TARN, which behavior was probably attributed to the adaptation to the culture medium in nutrient solution. In addition, the highest TARN values in the initial evaluation period are due to the small dry mass accumulation in jabuticaba seedlings (Table 1 and 2). Similar behavior was observed in star fruit (ROZANE et al., 2011a). This observation corroborates data obtained in stevia (DE LIMA FILHO et al., 1997). It is worth mentioning that the absorption index shows the highest nutrient concentration, and therefore, the highest TARN.

The mean macronutrient accumulations (TALON) were higher in leaves and stems of ‘Paulista’ species in the period from 180 to 270 DAT and from 270 to 360 DAT in ‘Sabará’ species. Only Mg in ‘Sabará’ leaves was accumulated in greater amount at 180-270 DAT. In the roots of jabuticaba seedlings, macronutrient accumulations were higher in the first period evaluated in ‘Paulista’ species and at 270 - 360 DAT in ‘Sabará’ species (Table 2).

Since these processes refer either to accumulation or loss of nutrient to other organs or to the external environment, it is understandable to find negative results (Table 2), a fact that indicates the net loss of a certain nutrient (ROZANE et al. al. 2011a).

At 450 days, it was observed that seedlings reached averages of 66.7 cm and 53.8 cm in length of shoots, respectively for ‘Sabará’ and ‘Paulista’ jabuticaba cultivars, similar to those suggested for the definitive planting of seedlings in the field, 60 cm (SOUZA et al., 2002). In conventional jabuticaba seedling production system, at 365 days of cultivation, average length of shoots of 23.7 cm was obtained (DANNER et al., 2007). This behavior may have occurred due to the cultivation in nutrient solution, which favors a reduction in the production time of fruit plants such as pear (*Pyrus* sp) (SOUZA et al., 2015) and peach (*Prunus persica* (L.) Batsch) (SOUZA et al., 2011).

There was an average increment at the end of the growing season of 84% and 82% in the dry matter of shoots and 16% and 18% in the dry matter of roots of 'Sabará' and 'Paulista' seedlings, respectively. These increases in dry matter were observed by Franco et al. (2008) in a study with guava seedlings (*Psidium guajava* L.), 'Paluma' and 'Século XXI' cultivars.

During the cultivation time, there were differences in the accumulation of macro and micronutrients in roots, stems and leaves of jabuticaba seedlings, in which greater accumulations were observed at 450 DAT. These data corroborate those observed by Augostinho et al. (2008) in 'Pedro Sato' guava seedlings grown in nutrient solution.

The average nutrient accumulations in jabuticaba seedlings were in the following order: leaves > stem > roots, coinciding with the pattern obtained for dry mass accumulation over time (Table 1 and Figures 1 to 4).

There was a linear increase for macronutrient accumulation in 'Sabará' cultivar, except for P in leaves and K in stem, which followed quadratic behavior. For macronutrient accumulation in 'Paulista' seedlings, quadratic behavior was observed for all macronutrients except for K and Mg in roots, which showed linear increases (Figures 1 and 2). Mg and Ca accumulated in leaves had linear behavior and did not differ statistically between cultivars (Figure 2- b, c).

The mean accumulations for all macronutrients were higher in stems and roots of 'Paulista' seedlings, and N, P and K in the leaves of 'Sabará' seedlings. (Figures 1 and 2). Unlike most macronutrients, S accumulation was higher in 'Sabará' leaves at 450 DAT in relation to 'Paulista' seedlings (Figure 2-a).

At 450 DAT, the following total macronutrient accumulations (root, stem and leaf) were obtained (mg plant^{-1}): N (706 and 611), P (81 and 62), K (541 and 409), Ca (488 and 424), Mg (66 and 54) and S (93 and 92), and 46 g and 37 g of total dry matter, respectively for 'Paulista' and 'Sabará' cultivars (Figures 1 and 2). The highest macronutrient accumulations in the different plant parts translate into higher dry matter production in the root system of 'Paulista' species, indicating its greater efficiency in the use of these nutrients compared to 'Sabará' species. Similar data were observed for macronutrient accumulation in guava cultivated in pots with sand submitted to nutrient solution application (SALVADOR et al., 1999).

It could be observed that at 450 DAT, the average macronutrient accumulation by jabuticaba seedlings obeyed the following order: N > K > Ca > S > P > Mg for 'Paulista' species and N > Ca > K > S > P > Mg for 'Sabará' species. This result demonstrates the importance of knowing the nutritional differences of each species aiming at the correct supply of each nutrient in order to obtain healthy and vigorous seedlings to achieve success in the orchard production enterprise. It was observed that nitrogen was the most required nutrient in the initial phase of the development of jabuticaba seedlings, which was also observed in guava, fruit of the same family (FRANCO et al., 2007).

For B and Fe, there were larger accumulations in the leaves of 'Sabará seedlings compared to 'Paulista' seedlings (Figure 3-a, b), the opposite occurred in stems (Figure 3-c, d), where higher Mn (Figure 3-f), Zn and Cu accumulations were also observed in this organ (Figure 4-c, d) at 450 DAT. In roots, greater Fe and Mn accumulations were observed in 'Sabará' seedlings in relation to 'Paulista' seedlings at 450 DAT (Figure 3-g, i), which had greater Zn accumulation in this organ (Figure 4-e). Mn, Zn and Cu in leaves (Figures 3-c; 4-a, b) and B and Cu in roots (Figures 3-h; 4-f) had linear behaviors (except for B in roots and Mn in leaves) and did not differ statistically between jabuticaba species (Figures 3 and 4). Therefore, it could be concluded that macro and micronutrients in the organs of jabuticaba species in which accumulations had linear behaviors had greater nutritional requirement at the beginning of the development of seedlings in nutrient solution.

The probable reduction of B concentration in stems and roots can be attributed to the dilution effect caused by the increase in the dry mass of the plant, which was continuous over time (Figure 3-e, h). B is an essential element for the formation of meristematic tissues and has influence on root development and nutrient uptake (ROSOLEM et al., 2012).

At 450 DAT, the total average micronutrient accumulation (root, stem and leaf) in μg plant^{-1} was: Cu (1578 and 1635), Fe (20887 and 19652), Mn (13975 and 13434), Zn (4921 and 4048) and B (642 and 764) and 46g and 37g of total dry matter for 'Paulista' and 'Sabará' cultivars, respectively (Figures 3 to 4).

The average micronutrient accumulation in 'Paulista' and 'Sabará' species obeyed the following order: Fe > Mn > Zn > Cu > B. In citrus, larger Mn and Fe accumulations were found in the root system of the rootstock (TECCHIO et al. 2006) and in guava seedlings cultivated in nutrient solution, higher Fe accumulation was observed in the root system (FRANCO et al. 2008).

It is common to find in literature variations in the order of nutrient absorption and accumulation in fruit plants, especially when using genetic materials, different culture media and environmental conditions. Franco and Prado (2006) studied nutrient accumulations in guava seedlings cultivated in nutrient solution and observed the following sequence: Fe > Mn > Zn > B > Cu, and only B and Cu differed from the micronutrient accumulation observed in ‘Paulista’ and ‘Sabará’ jabuticaba seedlings of the present study.

The micronutrient contents accumulated in the leaves of ‘Paulista’ and ‘Sabará’ jabuticaba seedlings were higher than results obtained by Franco and Prado (2006) with fruit of the same family (guava).

It was observed that, although they were submitted to the same nutrient solution, nutrient extraction occurred differently in the two jabuticaba species, and ‘Paulista’ species was more efficient in the flow of macro and micronutrients, since it absorbed larger amounts and produced more dry matter in roots than ‘Sabará’ species. This difference in the nutritional analysis of jabuticaba seedlings was also observed by Marschner (2012), who attributed to the kinetic parameters of nutrient absorption the influence of genetic factors, which in turn are related to the morphological and physiological characteristics of the plant.

In this work, jabuticaba seedlings grew and developed under nutrient solution without presenting symptoms of nutritional deficiency or toxicity, which is an efficient method for the production of seedlings, and Rozane et al. (2011a, b), Souza et al. (2011), Souza et al. (2013) and Souza et al. (2015) demonstrated the efficiency of cultivation under nutrient solution in the production of star fruit, peach, ‘Ponkan’ mandarin (*Citrus reticulata* Blanco) and grafted pear, respectively.

Table 1 - Average dry matter of roots (MSR), shoots (MSPA) and total (MST) of ‘Paulista’ and ‘Sabará’ jabuticaba seedlings cultivated in nutritive solution

DAT	Specie		MSR (g plant^{-1})	MSPA (g plant^{-1})	MST (g plant^{-1})
	‘Paulista’		0,24 ± 0,05 a	2,25 ± 0,37 a	3,00 ± 0,41 a
90	‘Sabará’		0,20 ± 0,01 a	2,00 ± 0,10 a	2,25 ± 0,10 a
		Average	**0,22 ± 0,04 B**	**2,12 ± 0,24 C**	**2,62 ± 0,27 C**
	‘Paulista’		1,08 ± 0,13 a	4,00 ± 0,10 a	5,00 ± 1,07 a
180	‘Sabará’		1,17 ± 0,14 a	4,00 ± 0,11 a	5,50 ± 0,23 a
		Average	**1,13 ± 0,13 B**	**4,00 ± 0,61 BC**	**5,25 ± 0,69 BC**
	‘Paulista’		2,58 ± 0,20 a	11,50 ± 1,40 a	14,00 ± 1,45 a
270	‘Sabará’		2,26 ± 0,34 a	13,25 ± 2,06 a	15,50 ± 2,40 a
		Average	**2,42 ± 0,33 B**	**12,37 ± 1,93 B**	**14,75 ± 2,09 B**
	‘Paulista’		6,10 ± 0,94 a	24,50 ± 4,30 a	30,75 ± 5,25 a
360	‘Sabará’		6,78 ± 0,95 a	28,50 ± 4,19 a	34,25 ± 5,14 a
		Average	**5,94 ± 0,95 A**	**26,50 ± 4,28 A**	**32,50 ± 5,20 A**
	‘Paulista’		7,71 ± 0,87 a	36,00 ± 4,93 a	42,75 ± 5,17 a
450	‘Sabará’		5,58 ± 0,60 b	30,50 ± 3,58 b	36,25 ± 4,18 b
		Average	**6,70 ± 1,02 A**	**33,25 ± 4,99 A**	**40,00 ± 5,97 A**

Averages of species followed by the same lowercase letter and averages of times followed by the same capital letter at the same time, both in *the column, do not differ statistically from each other by the Tukey test at 5% probability. DAT = Days After Transplanting.

Table 2 - Organogenic net accumulation rate (TALON) and relative absorption rate (TARN) of nutrients in the organs of 'Paulista' and 'Sabará' jabuticaba trees as a function of the growing time

E	Period Days	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
		TALON										
		---- mg g day^{-1} ----						---- µg g day^{-1} ----				
		Leaf										
P	90 – 180	0,023	0,000	0,007	0,008	0,001	0,000	-	-0,027	0,175	0,087	-0,065
S		0,018	0,001	0,008	0,012	0,001	0,002	-	-0,005	0,193	0,221	-0,005
P	180 – 270	0,058	0,005	0,031	0,036	0,005	0,006	-	0,326	0,918	1,118	1,216
S		0,040	0,002	0,022	0,024	0,003	0,005	-	0,203	0,822	0,645	0,737
P	270 – 360	0,037	0,003	0,022	0,028	0,002	0,003	0,035	0,205	2,289	0,922	0,270
S		0,050	0,004	0,029	0,030	0,002	0,007	0,061	0,113	2,859	1,279	0,052
P	360 – 450	0,023	0,002	0,017	0,009	0,001	0,002	-0,007	-0,029	0,566	0,536	-0,032
S		0,007	0,001	0,002	0,006	0,000	0,001	-0,012	0,052	1,019	0,679	0,009
		Stem										
P	90 –180	0,017	0,001	0,012	0,013	0,003	0,004	-	-0,050	-0,013	-0,114	-0,068
S		0,011	0,001	0,005	0,008	0,002	0,002	-	-0,011	0,036	0,002	-0,018
P	180 – 270	0,031	0,007	0,037	0,034	0,007	0,007	-	0,134	0,301	0,377	0,516
S		0,015	0,002	0,015	0,016	0,003	0,003	-	0,060	0,229	0,144	0,208
P	270 – 360	0,028	0,005	0,026	0,026	0,004	0,005	0,024	0,061	0,931	0,283	0,260
S		0,043	0,007	0,046	0,034	0,006	0,007	0,047	0,036	0,862	0,312	0,222
P	360 – 450	0,010	0,002	0,014	0,009	0,002	0,003	0,007	-0,004	0,066	0,351	0,036
S		-0,004	0,000	0,000	-0,001	0,000	0,000	-0,006	-0,008	-0,364	0,176	-0,025
		Root										
P	90 – 180	0,031	0,006	0,031	0,022	0,007	0,008	-	0,019	-0,209	0,072	0,026
S		0,025	0,004	0,020	0,019	0,005	0,007	-	0,022	0,693	0,207	0,059
P	180 – 270	0,016	0,004	0,027	0,016	0,003	0,005	-	0,032	0,552	0,228	0,117
S		0,006	0,001	0,011	0,006	0,001	0,002	-	0,016	0,43	0,111	0,039
P	270 – 360	0,024	0,005	0,027	0,020	0,004	0,006	0,007	0,037	1,305	0,113	0,191
S		0,034	0,006	0,032	0,022	0,005	0,008	0,015	0,049	1,801	0,239	0,193
P	360 – 450	0,006	0,001	0,005	0,003	0,001	0,001	0,005	0,002	0,284	0,154	0,039
S		-0,001	0,000	-0,001	-0,001	0,000	0,000	0,002	-0,006	0,642	0,194	0,004
Whole plant		TARN										
P	90 – 180	0,022	0,001	0,008	0,010	0,002	0,002	-	-0,002	0,115	0,086	-0,003
S		0,017	0,001	0,007	0,008	0,001	0,001	-	0,031	0,124	0,147	0,151
P	180 – 270	0,042	0,000	0,001	0,001	0,000	0,000	-	-0,003	-0,004	0,011	-0,006
S		0,026	0,001	0,004	0,004	0,001	0,001	-	0,022	0,079	0,099	0,088
P	270 – 360	0,031	0,000	-0,000	-0,000	0,000	0,000	0,026	-0,001	-0,004	-0,016	-0,003
S		0,045	0,001	0,006	0,006	0,001	0,001	0,049	0,049	0,132	0,139	0,152
P	360 – 450	0,015	0,000	0,000	0,000	0,000	0,000	0,002	-0,001	-0,002	0,001	-0,002
S		0,002	0,001	0,003	0,004	0,001	0,001	-0,008	0,023	0,260	-0,017	0,044

*E = Specie, P = 'Paulista', S = 'Sabará', DAT = Days After Transplanting.

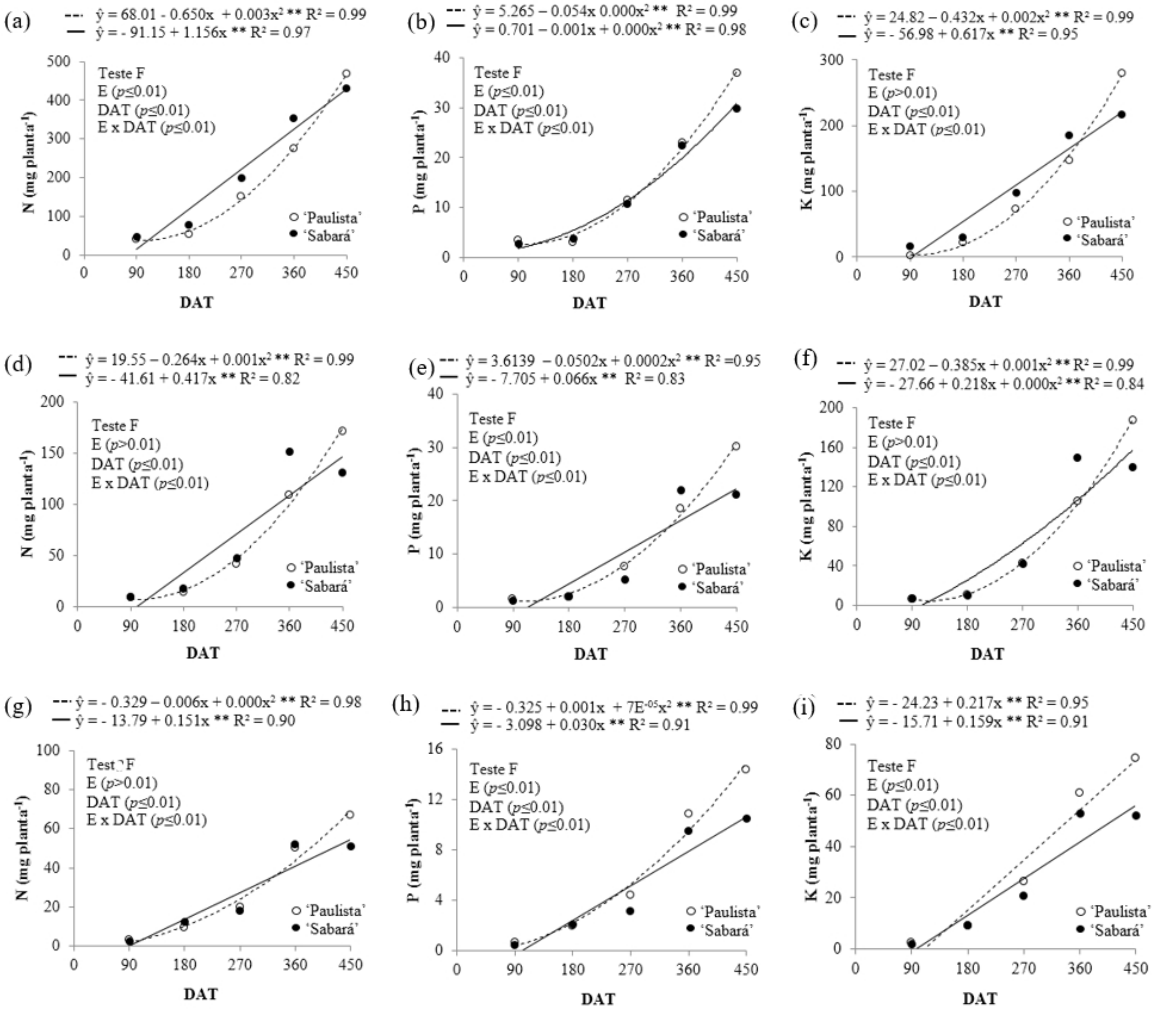

Figure 1 - Average accumulation of N, P and K in leaves (a), (b) and (c), stems (d), (e) and (f), and roots (g), (h) and (i) of ‘Paulista’ and ‘Sabará’ jabuticaba seedlings cultivated in nutrient solution according to the days after transplanting (DAT). ** - significant at 1%. S= Species.

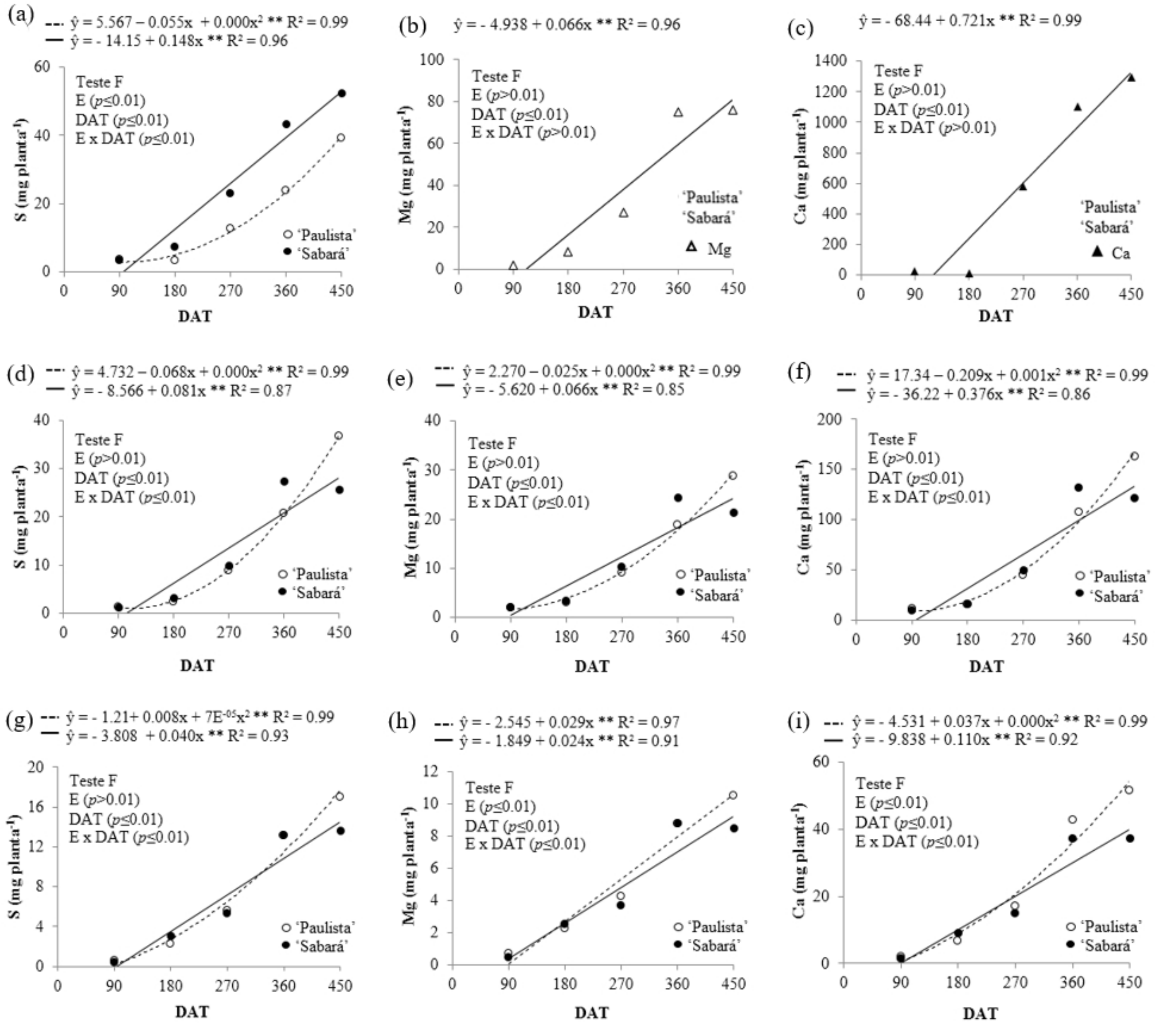

Figure 2 - Average accumulation of S, Mg and Ca in leaves (a), (b) and (c), stems (d), (e) and (f), and roots (g), (h) and (i) of 'Paulista' and 'Sabará' jabuticaba seedlings cultivated in nutrient solution according to the days after transplanting (DAT). ** - significant at 1%. S= Species.

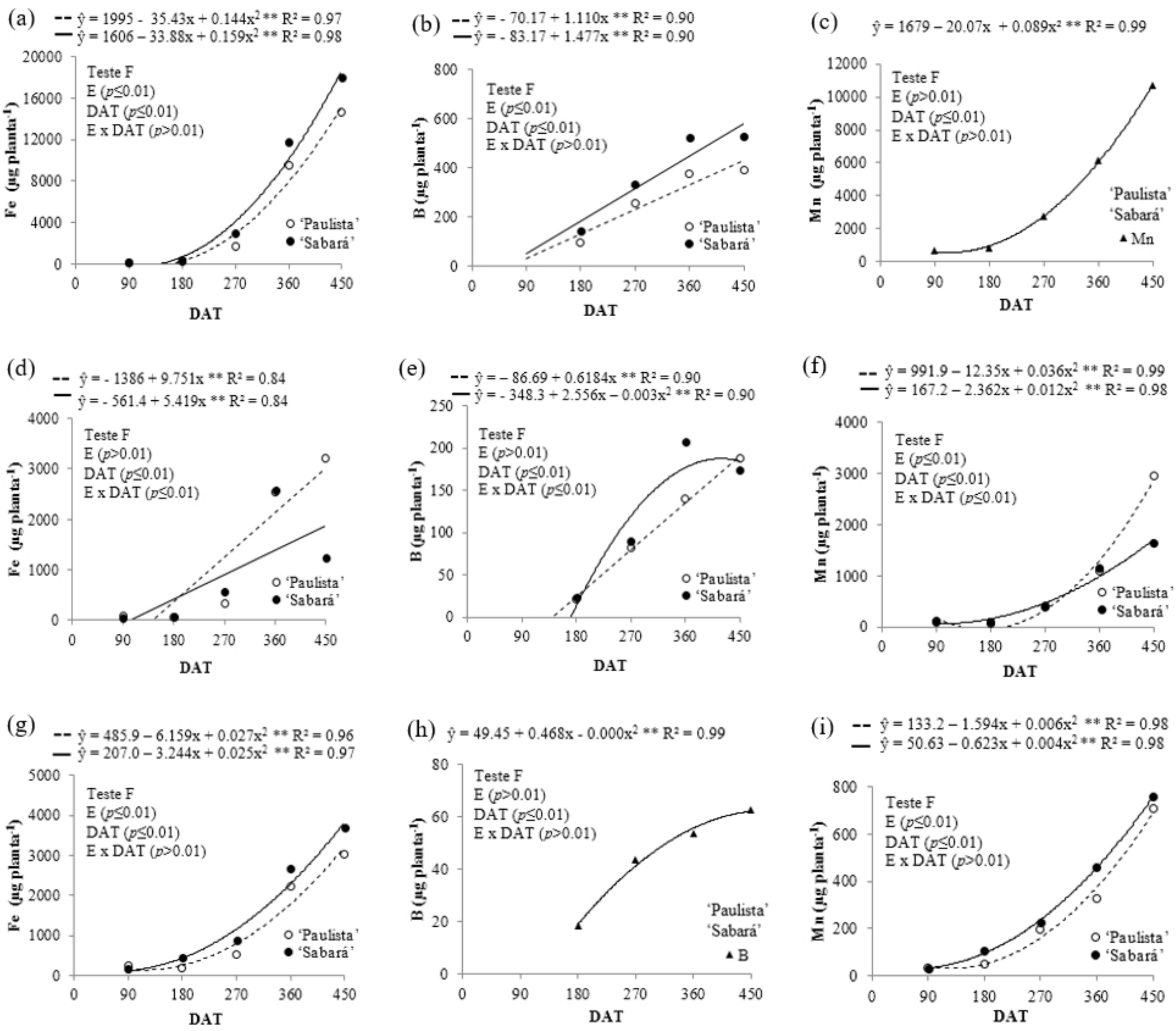

Figure 3 - Average accumulation of Fe, B and Mn in leaves (a), (b) and (c), stems (d), (e) and (f), and roots (g), (h) and (i) of 'Paulista' and 'Sabará' jabuticaba seedlings cultivated in nutrient solution according to the days after transplanting (DAT). ** - significant at 1%. S= Species.

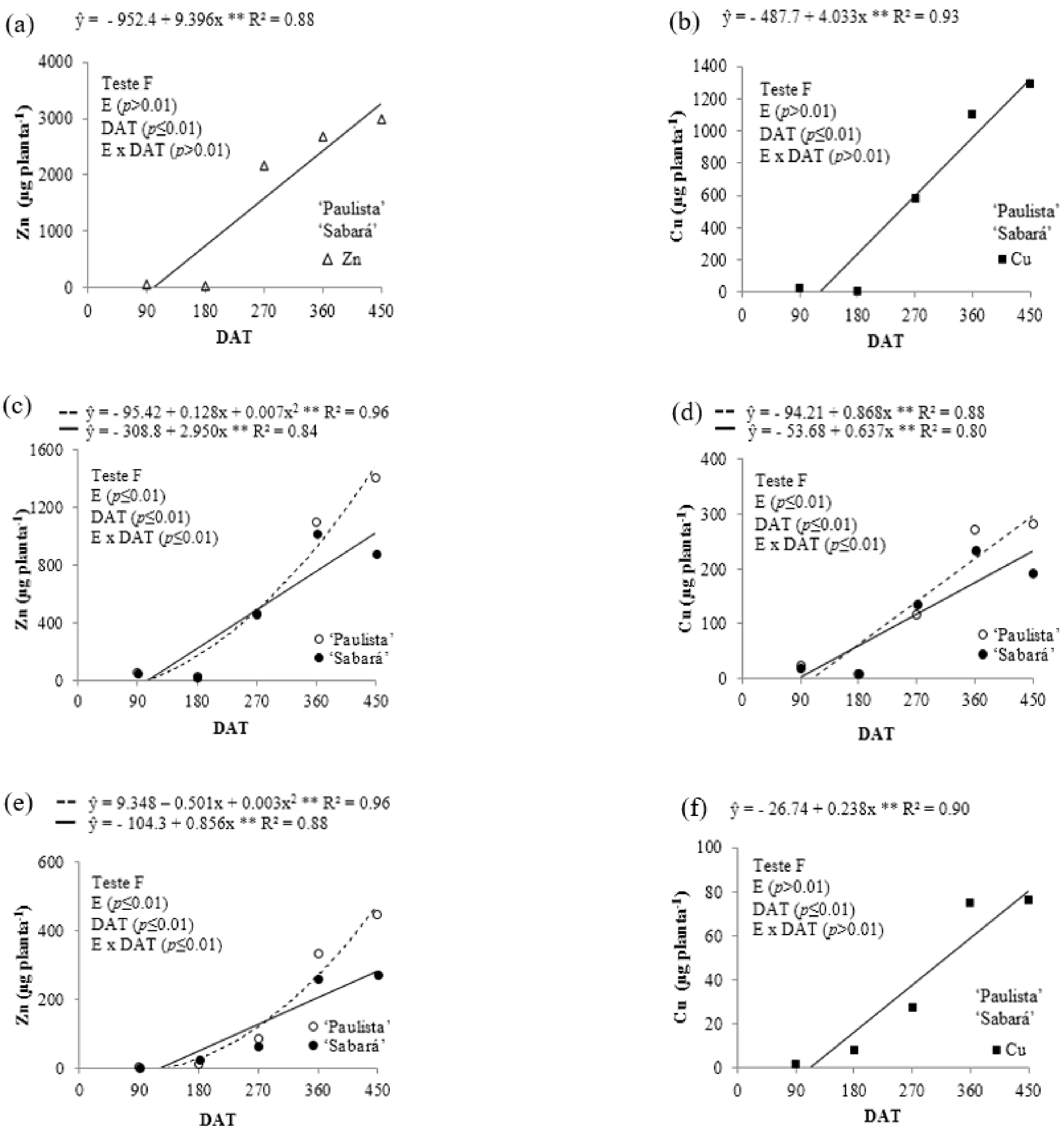

Figure 4 - Average accumulation of Zn and Cu in leaves (a) and (b), stems (c) and (d), and roots (e) and (f) of 'Paulista' and 'Sabará' jabuticaba seedlings cultivated in nutrient solution according to the days after transplanting (DAT). ** - significant at 1%. S= Species.

Conclusion

'Paulista' jabuticaba seedlings demanded more macronutrients.

Nutrient accumulation distribution among plant organs followed the sequence: leaf > stem > root, for 'Paulista' and 'Sabará' jabuticaba seedlings.

The maximum accumulation for the evaluated nutrients occurred at 450 days after transplanting of jabuticaba seedlings.

Macronutrient accumulation was different for the two species, 'Paulista' showing N > K > Ca > S > P > Mg and 'Sabará' N > Ca > K > S > P > Mg.

For micronutrient accumulation in 'Paulista' and 'Sabará' jabuticaba seedlings, the following sequence was obtained: Fe > Mn > Zn > Cu > B.

Acknowledgements

The authors would like to thank CAPES for the scholarship granted to the first author and CNPq for the financial support of the project.

References

AUGOSTINHO, L.M.D.; PRADO, R.M.; ROZANE, D.E.; FREITAS, N. Acúmulo de massa seca e marcha de absorção de nutrientes em mudas de goiabeira 'Pedro Sato'. **Bragantia**, Campinas, v.67, n.3, p.577-585, 2008.

CASTELLANE, P.D.; ARAÚJO, J.A.C. **Cultivo sem solo**: hidroponia. Jaboticabal: FUNEP, 1995. p.43.

DANNER, M.A.; CITADIN, I.; FERNANDES JÚNIOR, A.A.; ASSMANN, A.P.; MAZARO, S.M.; SASSO, S.A.Z. Formação de mudas de jabuticabeira (*Plinia* sp.), em diferentes substratos e tamanhos de recipientes. **Revista Brasileira de Fruticultura**, Jaboticabal, v.29, n.1, p.179-182, 2007.

DE LIMA FILHO, O.F.; MALAVOLTA, E., DE SENA, J.O.A.; CARNEIRO, J.W.P. Absorção e acumulação de nutrientes em estévia *Stevia rebaudiana* (Bert.) Bertoni: I. Macronutrientes. **Scientia Agricola**, Piracicaba, v. 54, n. 1-2, p. 14-22, 1997.

FERREIRA, D.F. Sisvar: a computer statistical analysis system. **Ciência e Agrotecnologia**, Lavras, v. 35, n.6, p. 1039-1042, 2011.

FRANCO, C.F.; PRADO, R.M. Uso de soluções nutritivas no desenvolvimento e no estado nutricional de mudas de goiabeira: macronutrientes. **Acta Scientiarum Agronomy**, Maringá, v.28, n.2, p.199-205, 2006.

FRANCO, C.F; PRADO, R.M; BRAGHIROLLI, L.F; ROZANE, D.E. Marcha de absorção dos micronutrientes para mudas de goiabeiras cultivares Paluma e Século XXI. **Bragantia**, Campinas, v.67, n.1, p.83-90, 2008.

FRANCO, F.C.; PRADO, R.M.; BRACHIROLLI, L.F.; ROZANE, D.E. Curva de crescimento e marcha de absorção de macronutrientes em mudas de goiabeira. **Revista Brasileira de Ciência do Solo**, Viçosa, MG, v.31, n.6, p.1429-1437, 2007.

JOLY, A.B. **Botânica**: introdução à taxonomia vegetal. São Paulo: Companhia Editora Nacional, 2002. p.777.

LORENZI, H. **Árvores brasileiras**: manual de identificação e cultivo de plantas arbóreas nativas do Brasil. Nova Odessa: Instituto Plantarum, 2008. p.384.

MALAVOLTA, E.; VITTI, G.C.; OLIVEIRA, S.A. **Avaliação do estado nutricional das plantas**: princípios e aplicações. Piracicaba: Potafós, 1997. p.319.

MARSCHNER, H. **Mineral nutrition of higher plants**. San Diego: Academic Press, 2012. p.651.

ROSOLEM, C.A.; DEUS, A.C.F.; MARTINS, P.O.; LÉLES, E.P. Acúmulo e distribuição de boro em cultivares de algodão. **Revista Brasileira Ciência do Solo**, Viçosa, MG, v.36, p.1231-1238, 2012.

ROZANE, D.E.; PRADO, R.M.; NATELE, W.; ROMUALDO, L.M.; SOUZA, H.A.; da SILVA, S.H.M.G. Produção de mudas de caramboleiras 'B-10' e 'Golden Star': I - Parâmetros biológicos. **Revista Brasileira de Fruticultura**, Jaboticabal, v.33, n.4, p.1300-1307, 2011b.

ROZANE, D.E.; PRADO, R. de M.; NATALE, W.; ROMUALDO, L.M.; SOUZA, H.A. de; SILVA, S.H.M.G. da. Produção de mudas de caramboleiras B-10 e Golden Star: II - Marcha de absorção e acúmulo de nutrientes. **Revista Brasileira de Fruticultura**, Jaboticabal, v.33, n.4, p.1308-1321, 2011a.

SALVADOR, J.O.; MOREIRA, A.; MURAOKA, T. Efeito da omissão combinada de N, P, K e S nos teores foliares de macronutrientes em mudas de goiabeira. **Scientia Agricola**, Piracicaba, v.56, n.2, p.501-507, 1999.

SOUZA, A.; DA SILVA, S.E.L.; DE SOUZA, M.G. **Produção de mudas frutíferas**. Manaus: Embrapa Amazônia Ocidental, 2002. (Circular Técnica)

SOUZA, A.D.G.; CHALFUN, N.N.J; FAQUIN, V.; SOUZA, A.A.D.: NETO, A.L.D.S. Massa seca e acúmulo de nutrientes em mudas enxertadas de pereira em sistema hidropônico. **Revista Brasileira de Fruticultura**, Jaboticabal, v.37, n.1, p.240-246, 2015.

SOUZA, A.G.; CHALFUN, N.N.J.; FAQUIN, V.; SOUZA, A.A. Production of peach grafts under hydroponic conditions**. Ciência e Agrotecnologia**, Lavras, v**.**35, n.2, p.322-326, 2011.

SOUZA, A.G.; FAQUIN, V.; CHALFUN, N.N.J.; SOUZA, A. A. Produção de mudas de tangerineira 'Ponkan' em sistema hidropônico. **Ciência Agronômica**, Fortaleza, v.44, n.4 p.296-297, 2013.

TÁVORA, F.J.A.F.; FERREIRA, R.G.; HERNANDEZ, F.F.F. Crescimento e relações hídricas em plantas de goiabeira submetidas a estresse salino com NaCl. **Revista Brasileira de Fruticultura**, Jaboticabal, v.23, n.2, p.441-446, 2001.

TECCHIO, M.A.; LEONEL, S; LIMA. C.P.; VILLAS BOAS, R.L.; ALMEIDA, E.L.P.; CORRÊA, J.C. Crescimento e acúmulo de nutrientes no porta-enxerto citrumelo 'Swingle', cultivado em substrato. **Bioscience Journal**, Uberlândia, v.22, n.1, p.37-44, 2006.

WELBANK, P.J. The effects of competition with Agropyron repens and of nitrogen and water supply on the nitrogen content of Impatiens parviflora. **Annals of Botany**, Oxford, v.26, n.103, p.361-373, 1962.